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WATER MONITORING REPORT

1992 HERBICIDE APPLICATION PROJECTS

ELDORADO NATIONAL FOREST

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ABSTRACT

As part of the Eldorado National Forest 1992 herbicide application projects, water and streambed sediments were monitored for glyphosate, triclopyr and hexazinone. Samples were collected before herbicides were applied and during post-application storms and snowmelt runoff. Glyphosate was detected in three streambed sediment pretreatment samples and one water pretreatment sample, either from laboratory error, from contamination by samplers, or from use by adjacent private landowners. On resampling after the first spring storm, glyphosate was detected in one sediment sample. No triclopyr was detected in any pretreatment or storm sample. Hexazinone was detected in 8 out of 25 snowmelt runoff water samples taken in the spring of 1993. The amount of hexazinone detected ranged from 1.0 to 19 ppb, within the expected levels stated in the Region 5 Final Environmental Impact Statement: Vegetation Management for Reforestation. Hexazinone continued to be detected in samples taken from three locations as long as 24 months after herbicide treatment.

I. INTRODUCTION

This document summarizes the water quality monitoring program implemented in conjunction with 1992 and 1993 herbicide applications on the Eldorado National Forest (ENF). Approximately 7000 acres of young conifer plantations were treated with the herbicides Accord (active ingredient: glyphosate), Roundup (active ingredient: glyphosate), Garlon 4 (active ingredient: triclopyr), Velpar L (active ingredient: hexazinone) and Pronone 10G (active ingredient: hexazinone) either alone or in combination. Application was by hand using backpack sprayers for liquid formulations (Accord, Velpar L and Garlon 4) and broadcast spreaders for the pelletized Pronone 10G. Each of the four Ranger Districts on the ENF completed an Environmental Assessment (EA) entitled "Vegetation Management in Conifer Plantations" documenting the decision to use herbicides. Each EA included a water quality monitoring plan detailing the surface water, groundwater and streambed sediment monitoring procedures for each district project. This report describes the rationale used for the risk assessment in the hydrology section of the EAs in Chapter 4. Environmental Consequences, the monitoring methods in the monitoring plans and the results to date of this monitoring effort.

Included in this report are results from spring 1992 applications of glyphosate on the Georgetown Ranger District, which had been planned in 1991 and assessed in the 1991 EA. Also included are results from the spring 1993 applications of glyphosate and triclopyr on the Georgetown Ranger District, which had been planned in 1992 and assessed in the 1992 EA.

The Final Environmental Impact Statement: Vegetation Management for Reforestation (FEIS) directs National Forests in Region 5 to include water quality monitoring to evaluate the effectiveness of project design in all projects involving herbicides (USDA, 1989). The FEIS requires chemical analysis of surface and ground water and streambed sediments to identify patterns of herbicide persistence, accumulation and mobility.

The FEIS also assumes that applicable Best Management Practices (BMPs) will be implemented for protection of water quality. BMP 5-10, Pesticide Application and Monitoring, makes three requirements: 1) determination if chemicals are applied safely, restricted to target areas, and have not resulted in unexpected non-target effects; 2) documentation and provision for early warning of possible hazardous conditions to downstream beneficial users of water; and 3) determination of the extent, severity, and probable duration of any potential hazard that might exist (USDA 1988 FSH 2509.22).

II. OBJECTIVES

Four objectives were identified in district monitoring plans: 1) to determine if herbicide has moved off-site after application and into water through overland flow, leaching and subsurface flow or attached to eroding sediment; 2) to determine the amount of chemical residue reaching water; 3) if chemical residue has entered water, to determine how long it continues to enter water; and 4) to comply with State water quality objectives and Best Management Practices as described in the Basin Plan (CVRWQCB, 1989). Information collected in the district monitoring was intended to be used to determine whether herbicide residue amounts were at any time in excess of expected levels stated in the FEIS or in excess of any standard developed by an appropriate regulatory agency.

Water quality standards and objectives for the ENF have been set by the State of California, Central Valley Regional Water Quality Control Board in the Water Quality Control Plan, as amended. Numerical standards have not been set for the herbicides used in this project. The narrative objectives applicable to this project are as follows: 1) No individual pesticide or combination of pesticides shall be present in concentrations that adversely affect beneficial uses; 2) Discharges shall not result in pesticide concentrations in bottom sediments or aquatic life that adversely affect beneficial uses; 3) Pesticide concentrations shall not exceed those allowable by applicable antidegradation policies; and 4) Waters designated for use as domestic or municipal supply should not contain concentrations of pesticides in excess of the Maximum Contaminant Levels set forth in the California Code of Regulations, Title 22, Division 4, Chapter 15.

The FEIS, in modeling potential human exposure to herbicides, assumed concentrations in drinking water sources to equal 10 parts per billion (ppb) of herbicide per pound of herbicide applied per acre (USDA, 1989). In estimating risks to aquatic species, the FEIS used EPA's Q-value criteria, which is the ratio of the predicted concentration of a chemical in water and the LC50 of that chemical. The LC50 is the concentration in water of the chemical which has been observed to be lethal to 50% of test animals in an acceptable, controlled bioassay. For a concentration to be considered below a level which may cause acute toxicity, the Q-value should be less than 0.1. Therefore, when residues are detected, the concentration may be considered to present a risk to aquatic life if it is greater than the appropriate LC50 divided by 10. This provides a margin of safety to account for the probability that some other organisms may be more sensitive to the chemical than the most sensitive test species. The ENF uses this concentration as a broad guideline, though it is only considered a water quality standard by CVRWQCB for irrigated agricultural drainage water, and does not necessarily apply to mountain streams (Yee, 1993).

A final appropriate set of guidelines is the EPA lifetime Health Advisory Levels for drinking water, adopted for individual chemicals. The values of these standards is given in Table 1, all chemical concentrations in parts per billion (ppb):

Table 1. Water Quality Guidelines Used by Eldorado NF for Herbicides.

Chemical	FEIS[1]	$LC_{50}/10$	EPA Lifetime Health Adv.
Glyphosate	28-61	530[2]	700
Hexazinone	11-36	32,000-42,000[3]	200
Triclopyr	40-97	74[4]	NA[5]

1 The range given reflects the "realistic" and "worst case" concentrations estimated in the FEIS.
2 48-hour LC50 for Daphnia magna, reported toxicity for Roundup (Weed Science Society, 1989)
3 96-hour LC50 for trout (USDA, 1984)
4 96-hour LC50 for trout (Weed Science Society, 1989)
5 The EPA has not issued a Lifetime Health Advisory concentration for triclopyr. Applying the same method used to develop the advisories for hexazinone and glyphosate yields 180 ppb.

III. METHODS

Beneficial Use Risk Assessment

The 1992 ENF herbicide application projects involved 649 individual units ranging in size from 1 to 55 acres scattered across Georgetown, Pacific and Placerville Ranger Districts. Each unit was treated with up to three different chemicals during three seasons of the year. In order to maximize effective and efficient use of available personnel and money, the monitoring program was designed to sample at the locations and times in which the probability of detecting herbicides in water would be highest. The hydrology section of Chapter 4, Environmental Consequences, in each District EA contained a Beneficial Use Risk Assessment which ranked the individual treatment units according to the risk to beneficial uses of water from the herbicide application. This assessment used three factors to prioritize treatment units for risk to water quality: 1) proximity of water to the unit; 2) the beneficial uses of that water; and 3) the herbicide prescription. The monitoring plan then used that prioritization to determine monitoring station locations, and for each location, approximate timing, which chemical to monitor, and which matrix (surface water, groundwater and/or streambed sediment) to monitor. The Beneficial Use Risk Assessments and monitoring plans were based on the following assumptions:

1. Best Management Practices (BMPs) will be implemented to protect water quality.

There are 7 BMPs that apply specifically to pesticide use (USDA 1988 FSH 2509.22). *BMP 5.8* requires that water quality and other hydrologic concerns be addressed in the Environmental Assessment and specific mitigation measures be identified for water quality protection in sensitive areas. *BMP 5.9* requires complying with all herbicide label instructions and restrictions. *BMP 5.10* requires implementation of a monitoring program.

Accidental spills present the greatest risk for introducing chemicals into water. Implementation of *BMP 5.11*, which limits the transportation of herbicides to designated routes, specifies batching and mixing locations and requires the maintaining of a spill kit on site, minimizes this risk.

There is a low risk of chemicals entering water from improper rinsing and disposal of herbicide containers. Implementation of *BMP 5.12*, requiring the contractors to dispose of rinse water on the treatment site and containers at approved dump sites, minimizes this risk.

The greatest risk of chemicals entering water during application would be herbicide drift into streams. *BMP 5.14* requires designating temperature, wind and relative humidity conditions in the prescription to minimize drift. *BMP 5.13* requires establishment of untreated buffer strips along streams or springs within or near treatment units to help ensure that any herbicide drift does not reach water. For the 1992 herbicide projects, the following buffer strips were prescribed:

Table 2. Buffer Widths by Stream Class and Herbicide

Georgetown Ranger District

Stream Class[1]	Herbicide	Buffer Width (one side)
2	All	200 feet
3	All	100 feet
4	All	50 feet

Placerville Ranger District

Stream Class[1]	Herbicide	Buffer Width (one side)
2-3	All	100 feet
4	All	50 feet

Pacific Ranger District

Stream Class[1]	Herbicide	Buffer Width (one side)
2-3	Hexazinone, triclopyr	100 feet
2-3	Glyphosate	50 feet
4	Hexazinone, triclopyr	50 feet
4	Glyphosate	25 feet

1 See Appendix A for description of stream class.

The buffer strip width was lowered on the Pacific RD for glyphosate compared with 1991. This was considered acceptable due to the lower risk of contamination to water from glyphosate and as a result of monitoring on the ENF 1991 projects.

2. Water sampling for "early warning" monitoring was not necessary for these projects, except as specified in the project spill plans.

In addition to the BMPs listed above, several other measures were taken which greatly reduced the likelihood of herbicide entering water during application. Application was by hand using backpack sprayers for liquid formulations and broadcast spreaders for pelletized herbicide. A colorant was added to the spray formulations to track drift. The Contracting Officer or a representative was present on site during application to visually monitor the application.

3. Stream class designation is an adequate index of beneficial uses for most streams on the forest.

Stream class was designated for all streams on the ENF during preparation of the Land and Resource Management Plan (LMP). Stream classification is a means of identifying resource values and beneficial uses associated with streams or stream segments in order to ensure adequate protection for those areas during management activities. The relative importance or significance of a stream or stream segment is based upon an evaluation of flow characteristics, present and foreseeable instream and downstream values and characteristics of the stream environment. (See Appendix A for stream class criteria).

State-recognized beneficial uses of all streams and springs, including Class 4 (ephemeral) streams, are non-contact water recreation, wildlife and, depending upon location, stock watering. Class 3 streams provide cold freshwater habitat and may also be used for cold water fish spawning depending upon stream size. In addition to the above beneficial uses, Class 2 streams provide water for contact water recreation and/or hydroelectric power generation. Class 1 streams provide water for domestic purposes in addition to the other beneficial uses.

Generally the beneficial use of greatest concern in these herbicide application projects was Cold Freshwater Habitat: water that provides a habitat to sustain aquatic resources associated with a cold water environment. Small domestic diversions in close proximity to treated units were identified during the planning process and unit prescriptions were changed to protect the water going to them.

4. Units close to Class 1, 2 and 3 streams have a greater risk than units far away from drainages or near Class 4 streams.

Location of the treated unit relative to a stream or spring and the size of that stream or spring influences the risk of chemical entering the water and the risk to beneficial uses of that water. The greater the distance, the more likely the chemical will get tied up in the soil and not reach the water.

The Class 1, 2 and 3 streams are either perennial (flowing all year) or intermittent with water flowing underground during portions of the year. These streams are generally larger, have a greater contributing area and possess more sensitive beneficial uses such as domestic use or fisheries than Class 4 streams. However, because these streams are bigger, there is more water available to dilute any contamination to undetectable levels. Class 4 streams are ephemeral draws which run water in direct response to precipitation events or large snowmelt runoff periods. Ridgetop units have the least risk because of the distances to drainages.

5. Units located in or near bedrock contact zones have a greater risk than other units when treated with a leachable chemical because of the potential for shallow aquifers and associated seeps and springs.

Shallow unconfined aquifers pose the greatest threat for off-site migration of chemicals in subsurface flow. Springs are common in areas where different bedrock units come into contact with each other. Units near known springs and seeps or located within bedrock contact zones have a risk of introducing contaminants into the shallow aquifer as well as to nearby streams.

6. Herbicides applied in the fall at the onset of the wet season have a greater risk of off-site movement than those applied in the spring and summer months.

In order for a chemical to move off-site and into water following herbicide application, a sufficient quantity of precipitation is necessary to provide the energy and medium for movement. A Mediterranean climate extends over most of the forest, producing warm, dry summers and cold, wet winters. The area is subject to strong flows of marine air from the Pacific Ocean in winter, resulting in the bulk of the year's precipitation. Precipitation amounts and intensities are partially a function of elevation, both increasing with elevation. Precipitation falls primarily as rainfall at lower to intermediate elevations. At higher elevations, precipitation comes mainly in the form of snow, and is not available to move the chemical until spring snowmelt. Summer precipitation is light and is generally limited to a few scattered thunderstorms.

7. Hexazinone poses a greater risk than glyphosate and triclopyr due to the time of application, and due to its long persistence time and greater mobility.

In addition to timing of application, the risk of chemicals entering water is also determined by application rate, persistence and mobility of the chemical. Glyphosate, a foliar-active herbicide, binds readily to soil particles and does not easily move through the soil. It degrades fairly rapidly (<3 months)(USDA, 1989). Untreated buffer strips along stream courses act as sediment filters to help prevent soil particles with glyphosate attached from reaching the stream. Glyphosate was applied as a 2 % solution of Accord (approximately 2.0 lbs active ingredient per acre) in June, July and August. During the summer there is low risk of rain from isolated summer thunderstorms occurring to carry glyphosate to the stream before it degrades below levels of concern.

Triclopyr was applied as a tank mix consisting of 1.5 % Accord (approximately 1.5 lbs. glyphosate per acre) and 1.0 % Garlon 4 (1.0 lbs. triclopyr per acre) on some units in the summer. Triclopyr is transported with sediment and in solution, however its persistence is short (<3 months in soil and 7 days in water)(USDA, 1989). Some leaching may occur in soils with low organic matter if high rainfall is received shortly after application.

Hexazinone, a soil-active herbicide, has the greatest risk of off-site movement into surface or groundwater. The granular formulation, Pronone 10G, was used on the ENF in 1992 at rates ranging from 20 to 30 lbs. per acre (2 to 3 lbs. active ingredient per acre). Soils on representative units were sampled for texture and organic matter prior to application to determine proper rates. Pronone 10G is applied in the fall or winter and requires water, either rain or snowmelt, to carry the hexazinone into the root zone. Hexazinone is soluble in water and leaches through the soil. It also has a long persistence time (12 months). During the fall and winter, there is the greatest risk of large storm events to carry the chemical off-site. Fall application in the snow zone has the potential for delivery of hexazinone to streams in the spring snowmelt runoff. (USDA, 1984; USDA, 1989)

In each District EA, the proposed treatment units were grouped into risk categories according to the assumptions listed above. For example, the 1992 Placerville Ranger District EA had the following risk groupings:

Least Risk	Group 1:	Non-chemical
	Group 2:	Ridgetop, all chemicals, & Class 4, Glyphosate
	Group 3:	Class 1, 2 & 3, glyphosate
	Group 4:	Class 4, glyphosate + triclopyr
	Group 5:	Class 1, 2 or 3, glyphosate + triclopyr
	Group 6:	Class 4, hexazinone
	Group 7:	Class 1, 2 or 3, hexazinone
Greatest Risk	Group 8:	Class 2, 3 or 4, hexazinone + contact zone

Each District EA had different groups delineated, depending upon the mix of units, but the process was the same. These risk rankings were then used to select which units to monitor and what to sample for.

Monitoring Locations

Several factors went into the selection of monitoring locations. The Beneficial Use Risk Assessment was used to prioritize units to monitor. First priority was to select monitoring locations that would monitor runoff from the units in the higher risk groups for each chemical. For example, on the Placerville District, locations were chosen to monitor units in risk groups 3 and 5 for glyphosate and triclopyr and units in risk groups 7 and 8 for hexazinone. Monitoring locations were generally selected to monitor runoff from a group of units rather than each individual unit. In this way, some units in lesser risk groups were also monitored.

Not all units which were identified as falling into the higher risk groups on each district were monitored, however. In cases where there were several higher risk units with similar characteristics, (e.g., same aspect, located in neighboring sub-watersheds, possessing similar slopes and soils) one or more locations were chosen to be representative of that situation rather than monitoring each and every unit. For the safety of the samplers, it was important to select monitoring locations that had good road accessibility during stormy conditions. It was also desirable, as much as possible, to chose locations that could be reached without walking or driving through a treated unit.

Once the units to monitor where chosen, general locations were selected on the site maps. Locations were selected that would be in close proximity to the most downstream unit in a group and such that it would capture the runoff from all tributaries coming from treated areas but not any others, and far enough downstream from the units to allow for mixing. In cases where treated units were close to privately-owned land, locations were selected upstream of the private land, if possible, so that the monitoring would not be influenced by any herbicide applications on the private land. Specific locations were selected in the field during the pre-treatment sampling. At that time any necessary adjustments were made to optimize the suitability of the site as a monitoring location.

To monitor the 1992 projects, 39 monitoring stations were established in streams on the affected Ranger Districts to monitor surface water and streambed sediment. Groundwater was monitored at one developed spring. Thirty-eight percent of the treated units and 75 percent of those treated units in the higher risk groups were monitored (Table 3).

Table 3. Number and Proportion of High Risk Units that were Monitored

District	# of Units	# of Units in Higher Risk Groups	% of Total Units Monitored	% of High Risk Units Monitored
Georgetown	194	40	23	65
Pacific	75	33	40	66
Placerville	106	35	64	94
Forest Total	375	108	38	75

Appendix B lists the monitoring locations, chemicals, and matrix sampled for each district. The difference in number of stations for each chemical reflects the relative use of each chemical in the district projects. Sediment samples were taken at many of the glyphosate and triclopyr monitoring stations because these chemicals strongly adsorb to organic and mineral particles. Sediments were monitored for hexazinone only at stations below selected high risk units because it does not strongly adsorb to sediment. Once hexazinone was detected in surface water and intensive water monitoring was initiated, sediment monitoring for hexazinone was discontinued. Since the greatest risk from contaminated sediments would be to water quality, the presence of detectable concentrations of hexazinone in water obviated the need for sediment samples.

Monitoring Schedule

The monitoring schedule for each station depended on the chemical being monitored, weather and streamflow. Pre-treatment samples were taken at all stations prior to herbicide application to serve as "control" samples. In some cases, no pre-treatment sample was taken at sites at which the stream was dry.

At stations monitored for glyphosate and triclopyr, a sample was taken during the first significant runoff-producing storm to occur within 90 days of herbicide application. If no such event occurred, no sample was taken. This schedule was changed from the 1991 monitoring plans, in which a sample was collected at many glyphosate and triclopyr stations within 48 hours of application, regardless of precipitation. Because no residues were detected in any of these samples, 48-hour post-treatment samples were discontinued in monitoring plans beginning in 1992. Because the summer 1992 applications of glyphosate on the Georgetown District were planned in 1991, 48-hour post-treatment monitoring was carried out at those stations.

For fall hexazinone applications, a sample was also collected during the first runoff-producing storm within 90 days of application. At many locations, the first storm after an October or November application occurred as snow, blocking access to the station and producing no direct runoff. In such cases, no sample was taken until the snow melted to produce runoff. A snowmelt runoff sample was collected at all stations in spring, 1993. For a selected number of stations, a sample was also collected either approximately one year after application (October-November, 1993), or approximately one year after the first snowmelt sample was collected (spring, 1994), or both times.

Groundwater was monitored at one developed spring for hexazinone. A pre-treatment sample was collected in November 1992. The spring was sampled again shortly after the first significant storm following herbicide application. The delay was to allow for the chemical to move through the soil profile to the shallow aquifer. This spring was resampled following snowmelt in April and again in August 1993.

Because hexazinone is considered to present a high risk of contamination to surface and ground water, detection of hexazinone in 8 snowmelt runoff samples triggered an intensive sampling schedule which continues as of June 1994.

Sediment samples were collected at selected stations on the same schedule as water samples.

Monitoring Procedures

Surface water samples were taken so as to be representative of the total volume of water passing the monitoring station at any moment. Samples were collected at the lower end of a straight, riffle section of channel near the center of the stream at a time when the herbicide was expected to pass the station. There were two types of samples: 1) 1 liter grab sample during a storm or snowmelt runoff and 2) 1 liter composite sample of 4 hourly 250 milliliter grab samples during a storm or snowmelt runoff. Composite samples were taken at several, but not all, monitoring stations near more sensitive treatment units. A composite sample increases the chance of picking up chemical in the sample because four samples are being taken instead of one.

Streambed sediments were sampled from selected stations to monitor herbicide accumulations. Each sample consisted of a 500 ml composite sample of fine silt and sediments collected from a depositional area in the stream channel near where the water samples were collected. Streambed deposits can act as a chemical sink. Sediment particles contaminated by herbicide residue may enter the stream system and settle out during low flow periods or chemical residue in the water may adsorb to sediments. This herbicide residue can go undetected by sampling water above the streambed.

Water and sediment samples were taken by District and SO personnel. Extreme caution was taken to prevent sample contamination. Sample containers were supplied by the laboratories. Water samples were collected in 1 liter amber glass bottles with teflon-lined lids. Sediment samples were collected in 500 milliliter glass jars.

Each sample bottle was identified as follows: 1) monitoring station ID number; 2) date and time of sample collection; 3) name of person collecting sample; 4) type of sample; and 5) chemical to be analyzed. A sample documentation form (Appendix B), which served as a "chain of custody" form, accompanied each sample. This form contained the label information plus the weather conditions, an estimate of stream discharge at the time of sampling, and remarks on any unusual occurrence that might have affected water analysis results.

Samples were transported in ice-filled coolers to the SO where they were stored in refrigerator until transported by car to the lab. Samples were taken to the lab within one week of collection. Samples were analyzed at State certified labs. Eureka Laboratories, Inc. of Sacramento, Ca. performed the glyphosate and triclopyr analyses. Hexazinone analysis was performed by AnLab Analytical Laboratory of Sacramento and Environmental Micro Analysis of Woodland, Ca.

The practice of collecting duplicate samples for freezing was discontinued in 1992 for two reasons: 1) the analysis of thawed duplicates in 1991 suggested that glyphosate and triclopyr may not be adequately preserved by freezing. (However, this may have been a result of laboratory irregularities which were uncovered by the U.S. Environmental Protection Agency in 1994.); and 2) it was recognized that the practice was not useful in indicating laboratory effectiveness.

Quality Control

Beginning in December, 1992 a quality control program was initiated for laboratory analysis of hexazinone. Field samples are collected on an irregular schedule and often without prior notice, as opportunities and conditions for collection arise. It was therefore not possible to submit quality control (QC) spikes and blanks

with every sample batch submitted to the lab. Instead, spikes and blanks were submitted 1-2 months apart and marked so as to be indistinguishable from field samples. QC samples were always submitted in batches that included some field samples. For those batches which included QC samples, the spike recovery percentages could be used to adjust the concentrations reported by the lab. For other batches, concentrations were adjusted by the lab's reported spike recovery.

IV. RESULTS

Complete tables with all results are listed in Appendix C.

Spring/Summer Accord and Garlon Application Monitoring

Applications occurred between early May and early August 1992 and, on the Georgetown District only, also between early May and late June 1993.

Glyphosate was detected in one pre-treatment water sample and three pre-treatment sediment samples in 1992. The concentration of glyphosate detected in the water pre-treatment sample was 186 ppb. Concentrations in the sediment pre-treatment samples were 52, 64, and 68 ppb. All were resampled, but treatment had occurred before resampling on units monitored by two of the sediment stations. Glyphosate was detected in one of the sediment resamples. No triclopyr was detected in any pretreatment water or sediment sample.

A small storm occurred on June 30, 1992 which dropped approximately 1 inch of rain across the Eldorado National Forest. Six water samples and one sediment sample were taken during the first storm. At the other stations, it was judged that insufficient runoff had occurred to warrant sampling. It is unclear whether sufficient runoff had been produced at the sampled stations, but they were analyzed nevertheless because of the high probability that no other event would produce runoff before 90 days had passed. Glyphosate residue was detected in the sediment sample, the same station for which glyphosate had been detected in a pre-treatment sample.

The first significant runoff-producing storm following herbicide application in 1992 occurred over October 29-31, 1992, during which 3 to 5.5 inches of rainfall fell across the ENF. By this time, 90 days had passed since glyphosate and triclopyr applications had been completed for all except one of the stations. That station was not sampled in the mistaken belief that 90 days had passed.

Glyphosate was detected in one pretreatment sediment sample taken on May 6, 1993 on the Georgetown Ranger District before the spring 1993 applications. On May 25, 1993, a significant storm dropped over 1.5 inches of rain on the lower elevations of the district. In the week before the storm Accord and Garlon had been applied on units monitored by three stations, including the one for which the positive result had been received. Water and sediment samples were collected at all three stations. All were analyzed for glyphosate and one water sample was analyzed for triclopyr. No herbicides were detected. A fourth station received no precipitation within the required 90 days.

Fall Pronone Application Monitoring

Pronone was applied between late October and late November 1992. No hexazinone was detected in any pretreatment sample.

Samplers were able to reach 12 out of 25 stations to sample during a first runoff-producing fall storm. No hexazinone was detected in any of those samples.

Snowmelt runoff samples were collected between mid April and early June 1993. The timing of sample collection depended on access to the monitoring stations. All 25 stations were sampled; eight had detectable

levels of hexazinone, ranging from 1.3 to 19 ppb. Because one of the objectives stated in the monitoring plans is to determine how long pesticide residues continue to reach water, a more intensive monitoring schedule was initiated for those stations with detections. Eventually three stations were selected for long-term monitoring, and monitoring continues to the present. Results from the long-term monitoring is presented in Appendix D.

Eight stations were sampled either approximately one year after application or approximately one year after the first detection. Residues were detected in five of the samples, ranging from 1.1 to 15 ppb.

V. DISCUSSION

Glyphosate and Triclopyr Monitoring

The glyphosate concentration reported in one pre-treatment water sample taken on the Pacific District in June, 1992 is approximately three times greater than the "worst case" concentration predicted in the FEIS. However, it is still less than one half of the LC50/10 of the most sensitive aquatic species tested. It is also less than one third of the EPA's Lifetime Health Advisory level (700 ppb). No private land exists in the basin above the water sample station. All reported sediment detections occurred on the Georgetown District at stations which may have collected water from adjacent private lands.

Since initial detections were reported in pre-treatment samples, it is extremely unlikely that they are true detections resulting from the ENF program. For the water sample, it is unknown whether the detection reported was due to laboratory error or to contamination by the samplers. In the case of the sediment samples, the reported detection could have resulted from private land herbicide use, from laboratory error, or from sampler error.

Because spring applications were timed to provide a long dry season before the first rain, there were few opportunities for sampling for glyphosate or triclopyr. Those samples that were collected showed no triclopyr detected and no glyphosate detected which is likely to have resulted from ENF applications.

Hexazinone

Results to date support the assumptions made in planning the 1992 herbicide program that hexazinone is a very mobile chemical which poses a high risk of contaminating ground and surface water. In the above normal precipitation winter of 1992-1993, hexazinone moved into the ground water of several drainage basins in concentrations high enough to continue to supply baseflow to streams for up to 24 months after application at the time of this report. This observed persistence is longer than that used to analyze risk in the FEIS, but within the 36 months persistence reported by Lavy, et al. (1989).

All river systems on the ENF eventually provide water for domestic purposes outside the forest boundary. No water sample had levels of hexazinone which are considered a risk to drinking water. Furthermore, detections occurred in small headwater streams. That water would be diluted to a level at which residues would be undetectable further downstream where the diversions occur.

The highest level of hexazinone detected in this monitoring effort was 19 ppb. The concentrations of hexazinone detected in all water samples are below the level used to predict human consumption risk in the FEIS. The levels were 10 to 200 times less than the EPA Lifetime Health Advisory level for hexazinone, which is 200 ppb. The EPA believes that water containing hexazinone at or below this level is acceptable for drinking every day over the course of one's lifetime (US EPA, 1988). The highest concentration detected is less than 0.06% of the concentration that would be needed to fall within the range of the Q-value for the most sensitive known species.

The results of the long-term monitoring which began with hexazinone discoveries in Spring 1993 have not yet been subjected to a full statistical analysis. However, they suggest a correlation between the percentage of area treated within a small drainage basin and observed concentrations in water discharged from the basin. Another likely correlation exists between volume of precipitation and herbicide concentrations. While this monitoring effort was not designed as a research project, it may add some useful information to the body of knowledge on the fate of hexazinone in the Sierras. It is hoped that this will lead to methods for predicting risk to water contamination based on area treated or predicted precipitation. Further study is needed to verify and refine this data.

VI. REFERENCES

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APPENDIX A - STREAM CLASS CRITERIA

STREAM CLASS CRITERIA

Class 1, Highly Significant: perennial or intermittent streams or segments that meet one or more of the following:

-habitat for large numbers of resident or migratory fish
-furnish water locally for domestic or municipal uses
-flows large enough to significantly influence downstream water quality
-have major fishing or other water-oriented recreational uses
-have special designation such as wild, scenic or recreational river
-have special visual or distinctive landscape features
-habitat for threatened or endangered animals and/or plants
-have significant ethnological, historical or archeological value

Class 2, Significant: perennial or intermittent streams or segments that meet one or more of the following:

-habitat for moderate numbers of fish
-furnish water locally for industrial or agricultural uses
-flows large enough to moderately influence downstream water quality
-have moderate fishing or other recreational uses
-have moderate visual quality value

Class 3, Moderately Significant: perennial or intermittent streams or segments that meet one or more of the following:

-habitat for few fish
-rarely used for fishing or other recreational purposes
-flows which exert minimum influence on downstream water quality
-have low visual quality value

Class 4, Minor Significance: intermittent or ephemeral streams or segments not previously classified.

APPENDIX B - WATER MONITORING STATION LOCATIONS

Table B1. 1991 Herbicide Water Monitoring Station Locations, Georgetown Ranger District

Station	Stream/spring	Legal Description	Chemical	Sample1

53A91	N F One Eye Trib	NW NW 12 T11N R11E	Glyphosate	W + S
53B91	N F One Eye Trib	NW NW 11 T11N R11E	Glyphosate	W + S
53C91	Long Canyon	NE NW 8 T13N R13E	Glyphosate	W + S
53D91	Ditch below 308-5	SW SW 18 T11N R11E	Glyphosate	W + S
53E91	Ditch below 308-17	SE SE 6 T11N R11E	Glyphosate	W + S

Table B2. 1992 Herbicide Water Monitoring Station Locations, Georgetown Ranger District

Station	Stream/spring	Legal Description	Chemical	Sample1
53B92	Rock Creek	SW SE 34 T13N R11E	Tri	W
53C92	Tobacco Gulch	SE SW 4 T12N R11E	Gly	W + S
53D92	Whaler Creek	NW SW 18 T12N R12E	Gly/Tri	W + S
53E92	Rubicon Trib	SE NW 4 T12N R13E	Gly/Tri/Hex	W + S
53F92	Spring, Nevada Pt. Ridge	SE NE 14 T13N R13E	Gly/Hex	W
53G92	S. Wallace	NE NE 11 T13N R13E	Hex	W
53H92	S. Wallace	NW NE 15 T13N R13E	Hex	W + S
53I92	N. Wallace	NW SW 2 T13N R13E	Gly/Tri	W + S
53J92	S. Br. Brushy	SW SE 2 T13N R12E	Gly/Hex	W
53K92	Long Canyon	NW NE 15 T13N R13E	Hex	W + S
53L92	Incline Creek	NE SW 2 T11N R13E	Hex	W

Table B3. 1992 Herbicide Water Monitoring Station Locations, Pacific Ranger District

Station	Stream	Legal Description	Chemical	Sample1
55A92	Trib to Brush Canyon	NW NW 17 T11N R14E	Hexazinone	W
55B92	Soldier Creek	NW NE 17 T11N R14E	Glyphosate	W + S
55C92	Soldier Creek	SE NE 16 T11N R12E	Hexazinone	W
55D92	Round Tent Canyon	NW NW 11 T11N R13E	Hexazinone	W + S
55E92	Trib to Silver Creek	NW NE 1 T11N R13E	Glyphosate	W + S
			Triclopyr	W + S
			Hexazinone	W
55F92	Trib Union Valley Res	SE NE 17 T12N R14E	Glyphosate	W + S
			Hexazinone	W
55G92	Trib Little Silver Cr	SE NW 4 T12N R14E	Glyphosate	W + S
			Triclopyr	W + S
55H*92	Unit 516-14	NE NW 25 T13N R14E	Glyphosate	W + S
55I92	Trib to Cheese Camp	NW SW 31 T13N R14E	Glyphosate	W + S
			Triclopyr	W + S
55J92	Poison Hole	SW SW 20 T13N R15E	Hexazinone	W
55K92	Deer Creek	SW SW 5 T13N R14E	Hexazinone	W + S

Table B4. 1992 Herbicide Water Monitoring Station Locations, Placerville Ranger District

Station	Stream	Legal Description	Chemical	Sample1
56A92	Long Canyon	NW NE 2 T10N R16E	Hexazinone	W
56B92	Trib Long Canyon	NW SE 3 T10N R16E	Glyphosate	W + S
			Triclopyr	W + S
56C92	Diamond Creek	NW NW 19 T10N R14E	Hexazinone	W
56D92	Bear Meadow Cr	SW SW 31 T10N R14E	Hexazinone	W
56E92	Trib NF Cosumnes	NE SW 5 T 9N R14E	Hexazinone	W + S
56F92	North F Cosumnes	NW SW 4 T 9N R14E	Glyphosate	W + S
			Triclopyr	W + S
56G92	North F Cosumnes	SE NW 11 T 9N R14E	Hexazinone	W
56H92	Trib NF Cosumnes	NE SW 7 T 9N R15E	Hexazinone	W
56I92	Trib NF Cosumnes	NW SW 8 T 9N R15E	Hexazinone	W + S

56J92	Trib NF Cosumnes	SW NW 15 T 9N R15E	Triclopyr	W + S	
56K92	Trib Alder Cr	NW 35 T10N R15E	Hexazinone		W
56L92	Big Canyon	NW NE 13 T 9N R13E	Glyphosate	W	
			Triclopyr		W
56M92	Long Canyon	NE SW 7 T 9N R14E	Glyphosate	W + S	
			Triclopyr		W + S
56N92	Trib Dogtown Cr	NW NE 28 T 9N R14E	Hexazinone	W	
56O192	Dogtown Creek	NW SE 22 T 9N R14E	Hexazinone	W	
			Glyphosate		W + S
			Triclopyr		W + S
56O292	Dogtown Creek	SW NW 23 T 9N R14E	Glyphosate	W + S	
			Triclopyr		W + S
56P92	Trib McKinney	SW NW 26 T 9N R14E	Glyphosate	W + S	
			Triclopyr		W + S
56Q92	McKinney Creek	SE SE 24 T 9N R14E	Hexazinone		W + S

1 W = Water, S = Sediment

APPENDIX C - SAMPLE ANALYSIS RESULTS

Water Monitoring for Glyphosate
1992 Vegetation Management Projects
Eldorado National Forest

Station	Treatment Date	Pre treatment	Post treatment	First Storm
(Results (ppb) and Sample Date)				
53A91	5/26/92	<25	<14	1ST STORM
	5/7/92	6/30/92	10/30/92	

53B91	5/25/92	<25	<14	1ST STORM	
5/7/92	6/30/92	10/30/92			
53C91	6/3/92	<25	<14	1ST STORM	
	5/12/92	6/30/92	10/30/92		
53D91	5/29/92	<25	NO WATER	1ST STORM	
	5/7/92	6/30/92	10/30/92		
53E91	6/2/92	<25	NO WATER	1ST STORM	
5/7/92	6/30/92	10/30/92			
53C92	5/18/93	<14	NA	<14	
	5/6/93	5/25/93			
53D92	5/93	NA	NA	<14	
5/25/93					
53E92	5/22/93	NA	NA	<14	
	5/25/93				
53I92	6/23/93	<14	NA	1ST STORM	
5/27/93	10/15/93				
55B92	6/26/92	<14	NA	<14	
	6/17/92	6/30/92			
55E92	7/2/92	NO WATER	NA	1ST STORM	
	6/17/92	10/30/92			
55F92	7/92	<14	NA	1ST STORM	
	6/17/92	10/30/92			
55G92	7/3/92	<14	NA	1ST STORM	
	6/17/92	10/30/92			
55H*92	7/15/92	186*	<14	1ST STORM	
	6/17/92	7/15/92	10/30/92		
55I92	7/92	<14	NA	1ST STORM	
6/17/92	10/30/92				

Station	Treatment Date	Pretreatment	Post-treatment	Storm
(Results (ppb) and Sample Date)				
56B92	8/4/92	<14	NA	NA
	5/27/92			

56F92	7/6/92 <14		NA	1ST STORM
	5/26/92	10/30/92		
56L92	6/19-7/3/92	<14	NA	<14
	5/26/92	6/29/92		
56M92	6/25-7/3/92	<14	NA	<14
	5/26/92	6/30/92		
56O192	7/16/92 <14		NA	<14
	5/27/92	5/26/93		

"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level. "NA" means no sample was taken.
* Resampled on 7/8/92, result <14 ppb.

Sediment Monitoring for Glyphosate
1992 Vegetation Management Projects
Eldorado National Forest

Station	Treatment Date	Pretreatment (Results (ppb) and Sample Date)	First Storm
53A91	5/26/92 <50	1ST STORM	
5/7/92	10/30/92		
53B91	5/25/92 52	<24	
5/7/92	5/30/92		
53C91	6/3/92 <50	1ST STORM	
5/12/92	10/30/92		
53D91	5/29/92 <50	NO WATER	
5/7/92	6/30/92		
53E91	6/2/92 64	<24	NO WATER
5/7/92	5/30/92	6/30/92	
53C92	5/18/93 <72	<24	
5/6/93	5/25/93		
53D92	5/93 68	<24	
5/6/93	5/25/93		
53E92	5/22/93 NA	<24	
5/25/93			
53I92	6/23/93 <24	1ST STORM	
5/27/93	10/15/93		
55B92	6/26/92 67	88	
6/17/92	6/30/92		

55F92 7/92 <240 1ST STORM
6/17/92 10/30/92

55G92 7/3/92 <240 1ST STORM
6/17/92 10/30/92

55H*927/92 <240 1ST STORM
6/17/92 10/30/92

55I92 7/92 <240 1ST STORM
6/17/92 10/30/92

56B92 8/4/92 <24 NA
5/27/92
T
Sediment Monitoring for Glyphosate, Page 2
1992 Vegetation Management Projects
Eldorado National Forest

Station Treatment Date Pretreatment First Storm

(Results (ppb) and Sample Date)

56F92 7/6/92 <24 1ST STORM
5/26/92 10/30/92

56M92 7/3/92 <240 1ST STORM
5/26/92 10/30/92

56O192 7/16/92 <24 1ST STORM
5/26/92 10/30/92
"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level.
"NA" means no sample was taken.
Water Monitoring for Triclopyr
1992 Vegetation Management Projects
Eldorado National Forest

Station Treatment Date Pretreatment First Storm
(Results (ppb) and Sample Date)

53B92 06/22/93 <0.1 1ST STORM
05/06/93 10/15/93

53D92 05/93 <0.1 <0.1
05/06/93 05/25/93

53I92 06/23/93 <0.1 1ST STORM
05/27/93 10/15/93

55G92 7/3/92 <1 1ST STORM
06/17/92 10/30/92

55I92 7/92 <1 1ST STORM
06/17/92 10/30/92

56B92 8/4/92 <1 NA
05/27/92

56F92 07/01-09/92 <1 1ST STORM
05/26/92 10/30/92

56J92 07/23/92 <1 1ST STORM
05/27/92 10/30/92

56L92 06/19-07/03/92 <1 1ST STORM
05/26/92 10/30/92

56M92 06/25-07/03/92 <1 1ST STORM
05/26/92 10/30/92

56O19207/11-20/92 <1 1ST STORM
05/26/92 10/30/92

"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level.
"NA" means no sample was analyzed.
Sediment Monitoring for Triclopyr
1991 Vegetation Management Projects
Eldorado National Forest

Station Treatment Date Pretreatment First Storm

(Results (ppb) and Sample Date)
55G92 7/3/92 <10 1ST STORM
06/17/92 10/30/92

55I92 7/92 <10 1ST STORM
06/17/92 10/30/92

56B92 8/4/92 <10 NA
05/27/92

56F92 7/6/92 <10 1ST STORM
05/26/92 10/30/92

56J92 7/23/92 <10 1ST STORM
05/27/92 10/30/92

56M92 7/3/92 <10 1ST STORM
05/26/92 10/30/92
BT

"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level.
"NA" means no sample was analyzed.

Water Monitoring for Hexazinone
1992 Vegetation Management Projects
Eldorado National Forest

Station	Treatment Date				
Pretreatment	First Storm	Snowmelt	1-Year		
(Results (ppb) and Sample Date)					
53E92	11/16/92	<1	<1	<1	NA
	11/11/92	12/7/92	4/22/93		
53F92	11/23/92	<1	<1	<1	<1
	11/9/92	12/10/92	4/22/93		10/15/93
53G92	11/13/92	<1	<1	1.3**	<1
	11/9/92	12/10/92	5/19/93	10/15/93	
53H92	11/16/92	<1	NA	1**	NA
	11/9/92	5/19/93			
53J92	11/11/92	<1	NA	<1	NA
	10/30/92	4/22/93			
53K92	11/13/92	NA	<1	<1	NA
	12/8/92	4/22/93			
53L92	11/18/92	<1	<1	<1	NA
	11/10/92	12/7/92	2/3/93		
55A92	10/24/92	<1	<1	<1	NA
	6/17/92	10/29/92	4/20/93		
55C92	10/25/92	<1	<1	<1	NA
	10/17/92	10/29/92	4/20/93		
55D92	10/24/92	<1	<1	<1	NA
10/17/92	10/29/92	4/20/93			
55E92	10/25/92	NO WATER	<1	<1	
NA					
	12/9/92	4/22/93			
55F92	10/24/92	<1	NA	<1	NA
6/17/92	4/22/93				
55J92	10/23/92	<1	<1	<1	NA
10/18/92	10/29/92	6/9/93			
55K92	10/23/92	<1	<1	<1	NA
10/18/92	10/29/92	6/9/93			
56A92	10/26/92	<1	NA	<1	NA

10/13/92 5/20/93

Water Monitoring for Hexazinone
1992 Vegetation Management Projects
Eldorado National Forest

Station Treatment Date
Pretreatment First Storm Snowmelt 1-Year

(Results (ppb) and Sample Date)

56C92 11/18/92 <1 <1 1.3** <1
10/13/92 12/9/92 5/20/93 4/7/94

56D92 11/17/92 <1 NA <1 NA
10/13/92 4/22/93

56E92 11/16/92 <1 NA <1 NA
10/9/92 4/29/93

56G92 11/10/92 <1 NA 3.1**1.1
10/9/92 4/29/93 4/1/94

56H92 11/10/92 <1 NA 6.8** 2.1
10/9/92 4/29/93 11/11/93

56I92 11/9/92 <1 NA 9.2** 1.2
10/9/92 4/29/93 11/11/93

56K92 11/3/92 <1 NA 19** 15
10/13/92 5/20/93 11/4/93

56N92 11/12/92 NO WATER NA <1 NA
4/15/93

56O292 11/12/92 NO WATER NA <1 NA
4/15/93

56Q92 11/12/92 NO WATER NA 4.3** 3.3
5/17/93 4/28/94

"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level.
"NA" means no sample was taken.
** - Detection of residues in snowmelt runoff triggered weekly monitoring at those locations. Results reported elsewhere.

Sediment Monitoring for Hexazinone
1992 Vegetation Management Projects
Eldorado National Forest

Station Treatment Date
Pretreatment First Storm Snowmelt

(Results (ppm) and Sample Date)

53H92	11/16/92	<100	NA	<100
11/9/92	5/26/93			
53L92	11/18/92	<100	<100	<100
11/10/92	12/14/92	2/2/93		
55D92	10/24/92	<100	<100	NA
10/17/92	11/4/92			
55K92	10/23/92	<100	<100	NA
10/18/92	11/4/92			
56E92	11/16/92	<100	NA	NA
10/9/92				
56I92	11/9/92	<100	NA	NA
10/9/92				
56Q92	11/12/92	<100	NA	NA
10/9/92				

"<" means the chemical was not detected and the number following is the analytical detection limit. For example, "<14" means the detection limit was 14 ppb and no residue was detected in the sample at that level. "NA" means no sample was taken.

APPENDIX D - LONG-TERM HEXAZINONE MONITORING

BTHexazinone Results: Eldorado NF Long-Term Monitoring

Date	53G92	53H92	56C92	56G92	56H92	56I92	56K92	56Q92
12/9/92			<1					

4/29/93			3.1	6.8	9.2		
5/17/93							4.3
5/19/93	1.5	1.2					
5/20/93		1.3				18.6	
5/26/93			<1	7.2	4.21		
6/17/93	1.5	2.2	<1*				3.1
6/22/93			<1	6.7	4.3		
6/29/93		<1	<1*	<1*	3.4	3.4	6.8	2.5
6/30/94	1.9						
7/7/93	1.3	<1		<1	2.8	1.7	6.6	2.5
7/14/94	1.5	<1					
7/15/93			<1*	<1	2.2	7.7	2.7
7/21/93	1.4	<1	1.1	<1*	4.2	2.7	9	2.9
2/27/23	1	<1					
7/28/93			<1*	<1*	2.8	2.1	8.8	2.0
8/3/93	1.2				3.9	3.0	9.8	
8/7/93			<1*					
8/10/93	1.6		<1	<1	2.5	1.7	7.1	1.0
8/17/93	<1				2.6	1.9	7.2	
8/25/93					4.2	2.5	12	
8/31/93				<1	3.8	2.7	8.4	
9/7/93					2.8	2.1	9.4	
9/14/93					2.4	2.0	7.4	
9/21/93					1.7	1.6	8.4	
10/4/93					3.9	2.3	10	
10/13/93						3.1	2.0	7.6
10/20/93						2.0	1.6	6.3

10/26/93			2.5	1.6	7.3
11/4/93		5.2	3.4	15	
11/11/93			2.1	1.2	7.3
11/17/93			1.4	1.3	5.1
11/24/93			2.0	1.7	5.8
12/2/93		2.6	2.4	9.3	
12/9/93		<1	1.8	9.3	
1/19/94		1.9	2.6	4.4	
3/4/94		1.6	<1	2.6	
4/1/94		2.7	3		
4/7/94				2.8	
4/28/94	<1(1.46)		3.3	1.8	3.3
5/2/94				3.8	
5/13/94	<1	1.8	1.8	2.7	
5/23/94		1.4	1.7	2.7	
6/3/94		3.1	3.1	3.6	
6/15/94		1.6	1.4	3.1	
6/28/94		2.3(2.7)			
1.4(1.9)					
3.6(4.2)					
9/2/94		3.8(3.8)			
1.9	5.1(5.7)				
9/30/94		2.0	1.3	4.3	
10/27/94			2.0	1.2	2.7

All results in ug/l (ppb), adjusted for spike recovery.
Numbers in parentheses are results from duplicate samples sent to second lab.